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No. EV 684377413 US

CLAIMS

1. The use of a buoyancy fluid presenting density that is less than that of sea water, and that is confined in a rigid or flexible leaktight casing (4_1, 19_1), so as to constitute an immersed buoyancy element (4, 19), said use being characterized in that said buoyancy fluid is a compound that is naturally in the gaseous state at ambient atmospheric temperature and pressure, and in the liquid state at the underwater depth to which said buoyancy element is immersed.

2. A use according to claim 1, characterized in that said buoyancy fluid is naturally in the stable liquid state when it is placed at an underwater depth of 10 m to 500 m, and preferably of 20 m to 100 m.

3. A use according to claim 1 or claim 2, characterized in that said buoyancy fluid is a fluid that is quasi-incompressible, and that presents a relative density in the liquid state of 0.3 to 0.8, and preferably of 0.5 to 0.7.

4. A use according to any one of claims 1 to 3, characterized in that said gas is selected from ammonia, a C-2 to C-7 alkane, a C-2 to C-7 alkene, a C-2 to C-7 alkyne, and a C-4 to C-7 diene.

5. A use according to claim 4, characterized in that said compound is selected from the list: ammonia, ethane, butane, propane, ethylene, propylene, butene, acetylene, methyl acetylene, propadiene, and butadiene.

6. A use according to claim 5, characterized in that said compound is selected from ammonia, propane, and butane.

7. A use according to any one of claims 1 to 6, characterized in that said casing is constituted by, or

is placed inside, the walls (4_1) of a compartment (4) of an immersed structure (1).

8. A use according to any one of claims 1 to 6, characterized in that said casing (19_1) is placed outside an immersed structure (1) to which it is connected or secured.

9. A use according to claim 8, characterized in that said immersed structure (1) is suspended from said buoyancy element (19) by at least one cable (59).

10. A immersed buoyancy element (4, 19) imparting buoyancy to an immersed structure (1) to which it is connected or secured, or in which it is integrated, said buoyancy element being characterized in that it comprises a said immersed casing (4_1, 19_1) in which said liquefied compound is confined in leaktight manner in accordance with the use of any one of claims 1 to 9.

11. A buoyancy element according to claim 10, characterized in that it comprises a said flexible casing (19_1), preferably having a hydrodynamic profile, minimizing forces during its vertical movements when it is full of said buoyancy fluid as defined in claims 1 to 6.

12. A method of putting a buoyancy element according to claim 10 or claim 11 into place between the surface and the bed of the sea, said method being characterized in that said fluid is stored in a tank on a surface ship (61) as a liquid in the cooled or compressed state, and it is injected in the liquid state into a pipe (23) from the surface (61) where it is stored to a said immersed casing (4_1, 19_1) at an underwater depth at which the underwater pressure is not less than the vapor pressure

of the gas corresponding to said compound at the ambient temperature at said depth.

13. A method according to claim 12, characterized in that said casing (19_1) is a flexible casing that is lowered to the desired depth empty, in a folded state.

14. A method according to claim 12 or claim 13, characterized in that said casing (19_1) is prefilled, at atmospheric pressure and temperature, with sea water or with another fluid, preferably an incompressible liquid compound such as gas oil, fresh water, or methanol, and the sea water or said other liquid is discharged from the casing as it fills with said buoyancy fluid as defined in claims 1 to 6.

15. A method according to claim 14, characterized in that said casing is prefilled with sea water, and before it is filled with a said buoyancy fluid, a limited quantity of methanol is injected, since methanol is suitable for preventing the formation of hydrates.

16. A method according to claim 14 or claim 15, characterized in that said casing is filled at the surface with a said other fluid, and said casing filled in this way is lowered to a depth at which the hydrostatic pressure corresponds to the pressure at which said buoyancy fluid is subsequently injected into said casing with said other fluid being discharged.

17. A method according to any one of claims 12 to 16, characterized in that said buoyancy fluid is stored as a liquid in the cooled state in a cryogenic tank and at atmospheric pressure, and it is injected in the pressurized liquid state into said immersed casing at a pressure corresponding to the hydrostatic pressure at the depth of said casing, said buoyancy fluid passing through

a heat exchanger so that the temperature of said fluid is brought substantially to that of the sea water at the depth of said immersed casing prior to filling said casing.

18. A device for stabilizing or controlling the lowering or raising of a structure (1, 32) between the surface (15) and the bed (7) of the sea, said structure including or being connected to a buoyancy element (4, 19) according to claim 10 or claim 11, said device being characterized in that it includes at least one connection element of the cable (12) or chain type, having:

· a first end that is connected to a winch (12_1) on board a floating support or ship (20a, 20b) on the surface, and on which winch it is wound; and

· a second end that is connected to a fastener element (10, 36) on said structure (1, 32), or on at least a first buoyancy element (19) according to claim 10 or claim 11 that is connected to said structure; and

· the length of said connection element (12) is such that said winch (12_1) is capable of winding or unwinding said first end of said connection element (12), so that a bottom portion (13) of said connection element (12) can hang beneath said fastener element (10, 36).

19. A device according to claim 18, characterized in that it includes at least two of said connection elements (12), said fastener elements (10, 36) preferably being disposed symmetrically, respectively around and on the periphery of said structure (1, 32).

20. A device according to claim 18 or claim 19, characterized in that said connection element (12) is constituted by a cable having a bottom portion (13) that comprises weighting blocks (31) disposed in a string on a said cable, said weighting blocks preferably being metal blocks secured to said cable by clamping.

By Express Mail
No. EV 684377413 US

21. A device according to claim 20, characterized in that said blocks (31) present a shape such that when said bottom portion (13) hanging beneath said fastener elements curves, two of said blocks (30) disposed side by side are capable of coming into abutment against each other, thereby limiting the curvature of said cable.

22. A device according to claim 21, characterized in that the curvature of said cable is limited so that the minimum radius of curvature (R_0) of said cables at said bottom portion (13) enables a minimum distance ($2R_0$) to be maintained between said cable (12) and said structure (1, 32) that is sufficient to prevent any mechanical contact between them while said structure is being lowered or raised.

23. A device according to any one of claims 20 to 22, characterized in that each of said blocks (31) present a cylindrical central portion (31) between two frustoconical ends (31_2) having axes that correspond to the direction of said cable (12) when said cable is disposed linearly, two adjacent blocks being in contact at said frustoconical ends along a generator line (31_2) of said frustoconical ends in the curved parts of said bottom portion (13).

24. A device according to claim 18 or claim 19, characterized in that said connection element comprises a chain having a bottom portion (13) that comprises links that are heavier than the links of the rest of the chain, and that are preferably larger so as to limit any curvature of the chain.

25. A device according to any one of claims 18 to 24, characterized in that said first buoyancy elements (19) are disposed above said structure.

26. A device according to any one of claims 18 to 25, characterized in that said structure includes second buoyancy elements (4, 33), preferably according to claim 10 or claim 11, that are integrated in said structure (1, 32), and more preferably integrated above said fastener element(s) (10, 36) so that the center of gravity of said structure together with said first buoyancy elements according to claim 10 or claim 11 is situated below the center of thrust that is exerted both on said structure (1) and on said first buoyancy elements (19) according to claim 10 or claim 11.

27. A method of lowering, raising, or stabilizing a structure (1, 32) between the surface (15) and the bed (7) of the sea by means of a device according to any one of claims 18 to 26, said method being characterized in that it comprises the following steps: unwinding or winding each connection element at its first end by means of a said winch (12_1); and controlling the speed at which each connection element is lowered or raised by regulating the speed at which each connection element (12) is respectively wound off or on said winch (12_1), so as to adjust the length of said bottom portion (13) of said connection element (12) hanging beneath said fastener element (10, 36), the lowering, raising, or stabilizing of said structure being obtained when the sum of the weight of the fraction of said bottom portion(s) (13) of the connection element(s) (12) between firstly said fastener point(s) for fastening to said fastener element(s) (10, 36) and secondly the lowest point of said bottom portion(s) (13), plus the weight of said structure (1, 32) as a whole and of said first buoyancy element(s) (19) according to claim 10 or claim 11, is respectively greater than, less than, or equal to the buoyancy thrust that is exerted on said structure (1, 32) and on said

first buoyancy element(s) (19) according to claim 10 or claim 11.

28. A method according to claim 27, characterized in that said structure is a rigid structure of steel, other metal, or composite synthetic material containing at least one and preferably a plurality of leaktight buoyancy compartments (4) that are suitable for forming a said buoyancy element according to claim 10 or claim 11, with each of said compartments being fitted with at least one filling orifice (4_1) and preferably with at least one emptying orifice (4_5), said leaktight compartments (4) preferably being distributed symmetrically in said structure.

29. A method according to claim 27 or claim 28, characterized in that said structure is a massive structure constituted by an open-based receptacle (1) in the form of a cap, the receptacle comprising a peripheral side wall (2, 2a, 2b, 2_1) surmounted by a roof wall (3, 3a, 3b) and being suitable for completely covering a wreck (6) of a ship on the sea bed (7) in order to recover polluting effluent (8) escaping therefrom, said receptacle having at least one emptying orifice (9) for discharging said effluent contained in the inside volume of said receptacle; said emptying orifice (9) preferably being situated in the roof (3, 3a, 3b) of the receptacle.

30. A method according to claim 28 or claim 29, characterized in that said receptacle is constituted as an upside-down double-walled ship hull, said leaktight compartments (4) being defined by spaces between said double walls and by structural elements (4_3, 4_6) interconnecting the double walls (2, 2a, 2b, 2_1, 3, 3a, 3b).

31. A method according to any one of claims 27 to 30, characterized in that the rigid structure includes hollow tubular bars defining leaktight compartments (4) and forming said buoyancy elements according to claim 10 or claim 11.

32. A method according to any one of claims 27 to 31, characterized in that said structure is fitted on the outside:

· with fastener elements (10, 14_1) enabling said buoyancy elements and said cables (12, 14) or said chains (13) to be secured thereto for lowering said structure from the surface (15), and for putting it into place, and, where appropriate, anchoring it (15_1, 15_2) to the sea bed (7); and

· preferably with thrusters (16), more preferably steerable thrusters enabling said structure to be moved in a horizontal direction in order to position it.

33. A method according to any one of claims 27 to 32, characterized in that it comprises the following steps:

1) filling said leaktight compartments (4) completely or partially with a said buoyancy fluid, so as to constitute a buoyancy element according to claim 10 or claim 11, with the extent to which said leaktight compartments (4) are filled being adjusted so as to cause said structure (1) to occupy an equilibrium position when immersed close to the surface;

2) lowering said structure (1) to the desired position by means of a device according to any one of claims 16 to 24 for controlling lowering, so as to regulate the speed at which the receptacle is lowered, and so as to provide equilibrium to the base of said substantially horizontal structure while it is being lowered; and

3) once said structure (1) is immersed to the desired depth, emptying said leaktight compartments (4)

By Express Mail
No. EV 684377413 US

filled with fluid lighter than sea water that is recovered at the surface, and simultaneously filling said leaktight compartments with sea water.

34. A method according to claim 33, characterized in that

· in step 1), additional buoyancy is provided to said structure by means of said first buoyancy elements (19) consisting of additional floats (19) connected to said receptacle; and

· in step 3), once said structure is in the underwater position at the desired depth, said additional floats (19) are detached.

35. A method according to claim 33 or claim 34, characterized in that after step 1) and before step 2), once said structure (1) has reached the desired position, in particular in the vicinity of the sea bed, the lengths of said heavy stabilizing cables (or chains) (12) hanging beneath said fastening elements (10, 10a, 10b) are reduced so as to stabilize said structure (1) in suspension, and

· where appropriate, said structure (1) is anchored (14, 15_1-15_2) to the sea bed (7), and then

· said heavy stabilizing cables (or chains) (12) are fully lowered so that their entire weight contributes to stabilizing said structure.

36. A method according to claim 35, characterized in that

· in step 1), said compartment(s) (4) or casing(s) (19_1) connected to said structure are filled with sea water or with a first fluid that is lighter than sea water; and

· in step 2), said structure (1) is lowered to a depth of 30 m to 60 m corresponding to a pressure of 3 bars to 6 bars, at which depth a buoyancy fluid, as defined in any one of claims 1 to 6, consisting of a liquefied gas that is lighter than sea water is injected

under pressure into said compartment(s) (4) or casing(s) (19_1) from a gas tanker ship (61) on the surface, so as to constitute a buoyancy element according to claim 10 or claim 11.

37. A method of recovering polluting effluent that is lighter than sea water, as contained in the tanks of a shipwreck (6) lying on the sea bed (7), in which method:

1) a said receptacle is put into place in accordance with the method of any one of claims 29 to 36; and

2) the effluent recovered inside said receptacle (1) is collected by being emptied out through said top emptying orifice (9).